Controlling Urban Epidemics of West Nile Virus Infection

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Research

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Original Investigation

The 2012 West Nile Encephalitis Epidemic in Dallas, Texas

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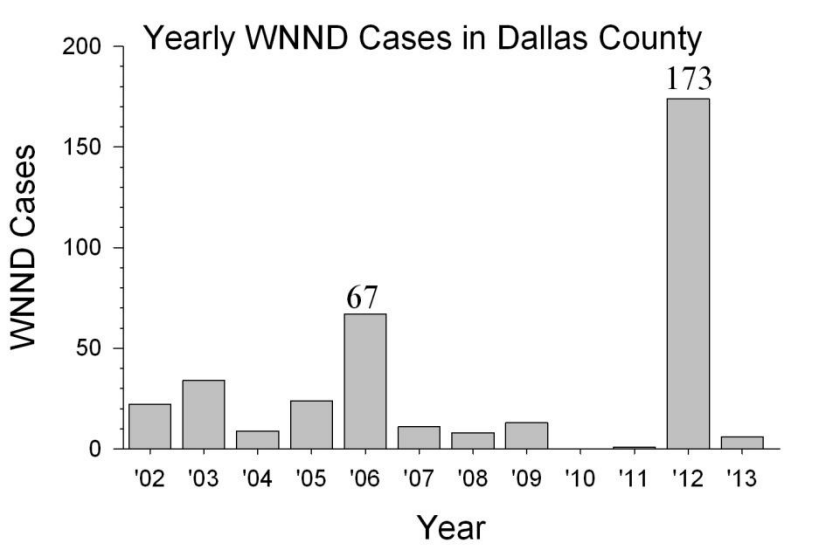

2012 Clinical Presentations

WNF only	225	
WNND	173	
Encephalitis		92
Meningitis		77
Cranial nerve palsy		3
Polio-like paralysis		1

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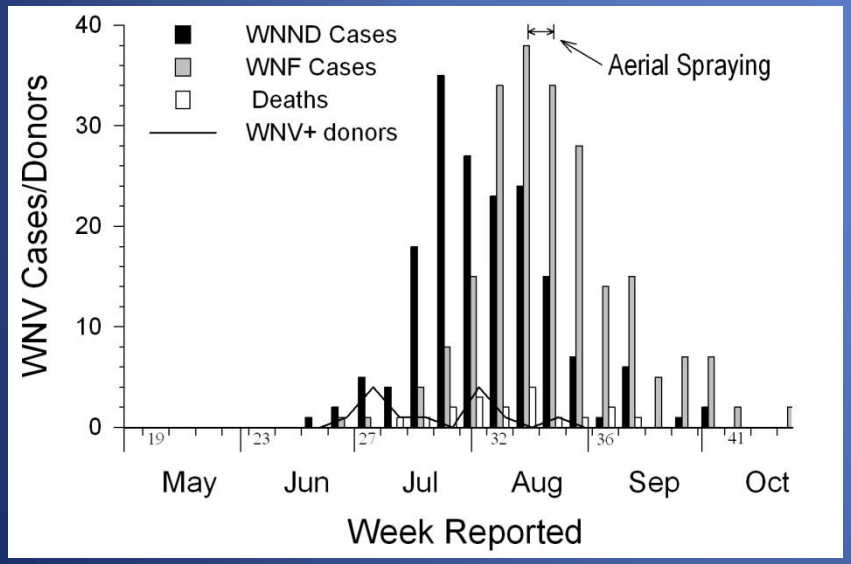


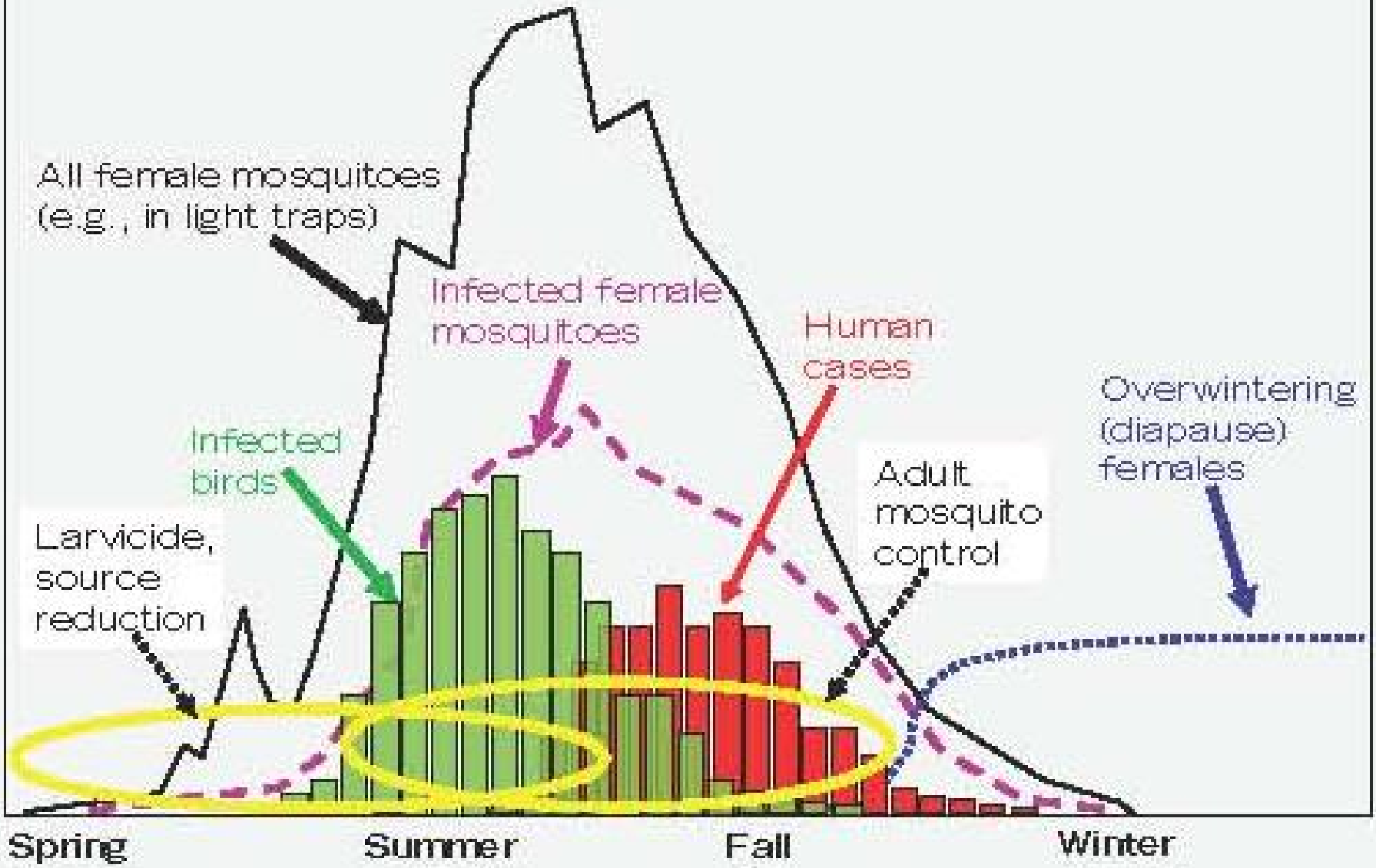
Shows the late summer, early fall timing.

WNF reporting influenced by awareness.

Note early reports of WNV+ blood donors.

Aerial spraying recommended early August, and carried out August 16-23.

Mosquito-Bird-Human Cycle of WNV



Causes of Urban WNV Epidemics: The Vector

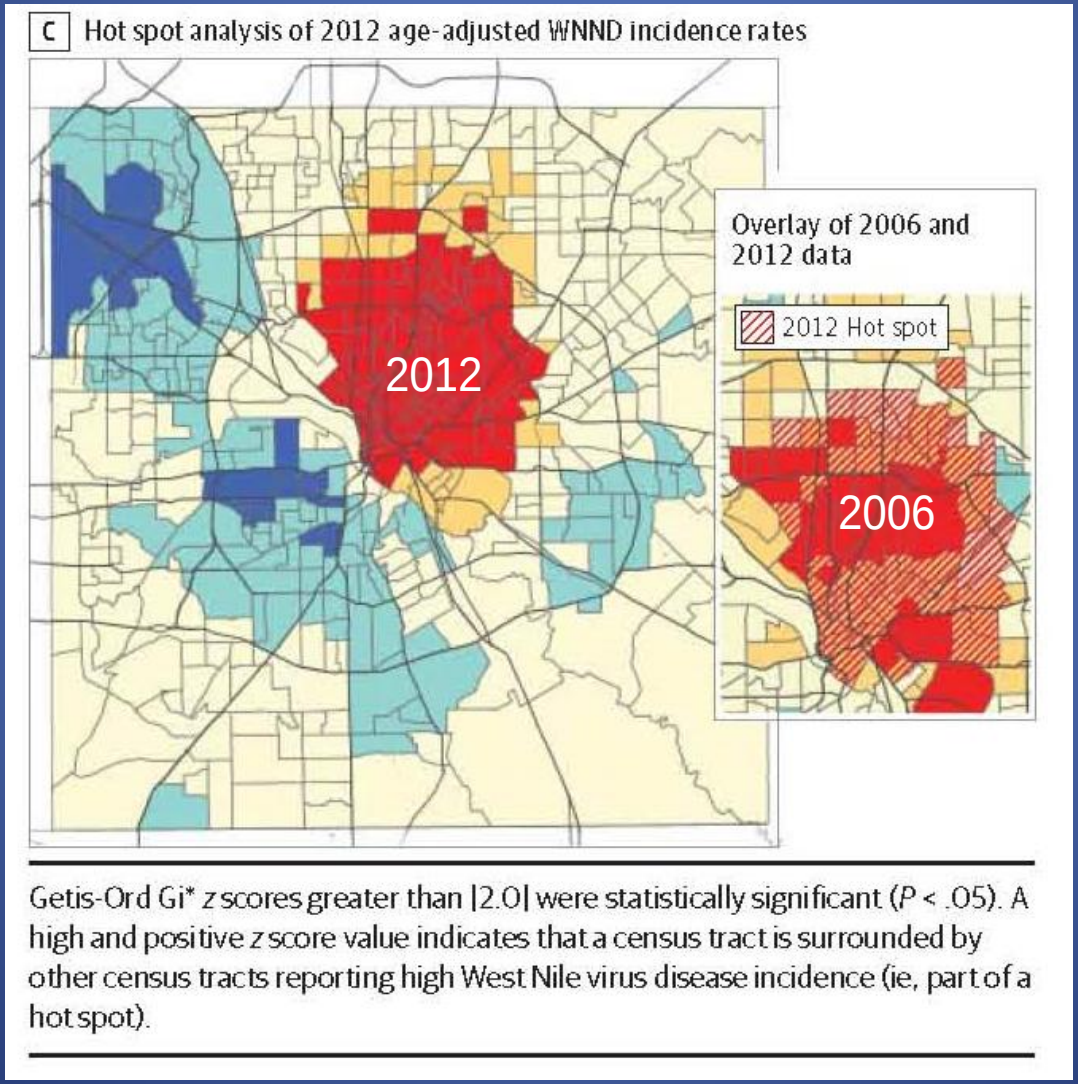
- The common house mosquito: *Culex quinquefasciatus ("quinks")*
  (Not the rural mosquito: *Culex tarsalis*)
- Breeds in small water sources around homes: bottle caps, French drains, overwatered lawns, bird baths, tires, neglected swimming pools.
- "Canopy dwellers" – 80% in tree tops, 20% near ground.
- May live all summer, overwinter, vertical transmission to eggs.
- Remains near breeding site
  (*Culex tarsalis* ranges far—possible explanation for westward spread)

Aedes albopictus, Asian Tiger Mosquito

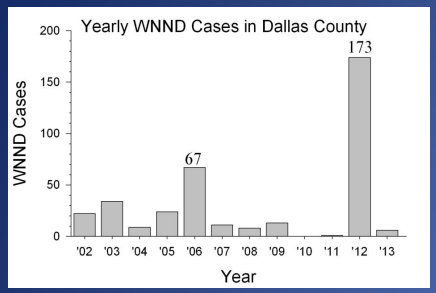
Culex quinquefasciatus, Southern House Mosquito

Recurrent Geographic Foci

GIS “hot spot” analysis, Dallas 2006 & 2012

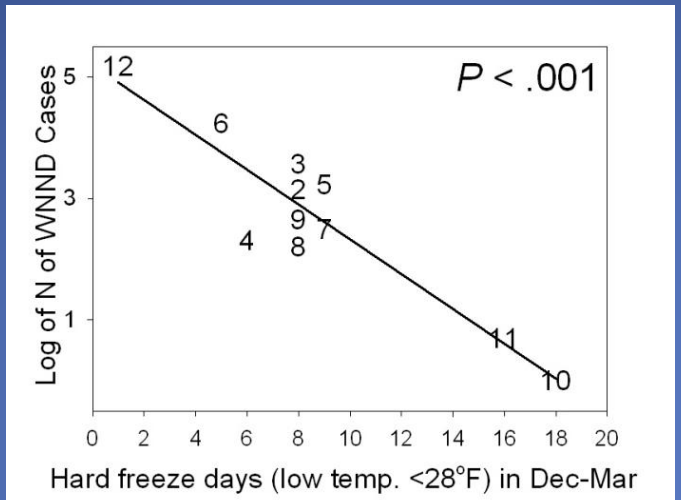


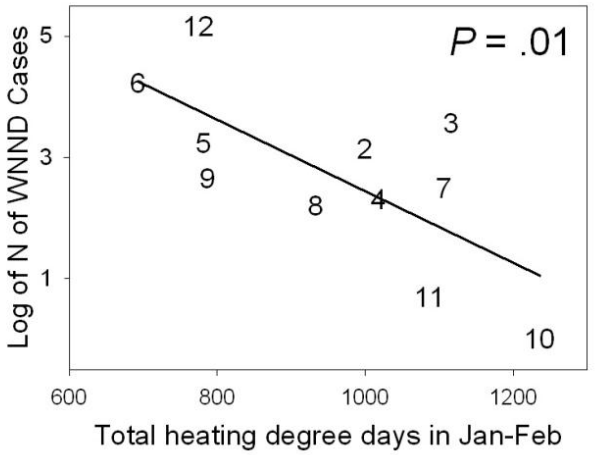
Effect of Weather on WNV Activity, 2002-2013

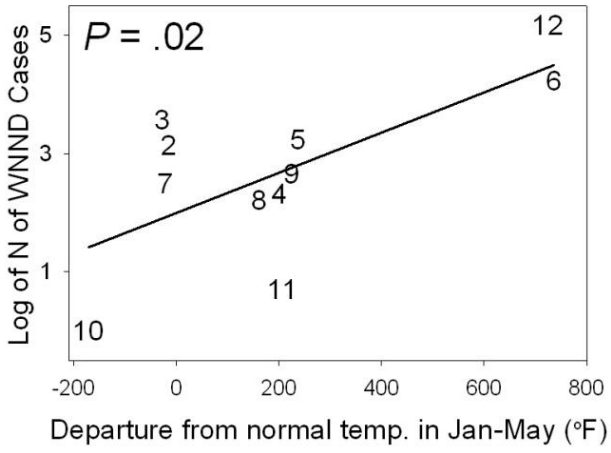


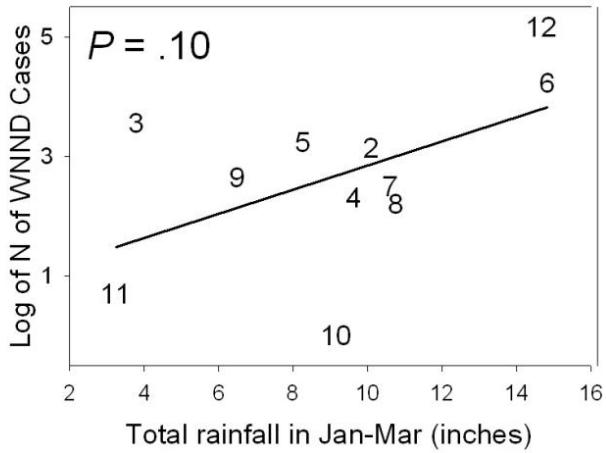
Suspected contributors to large WNV epidemics:

- Little winter freeze
- Warm winter & spring
- Increased spring rain





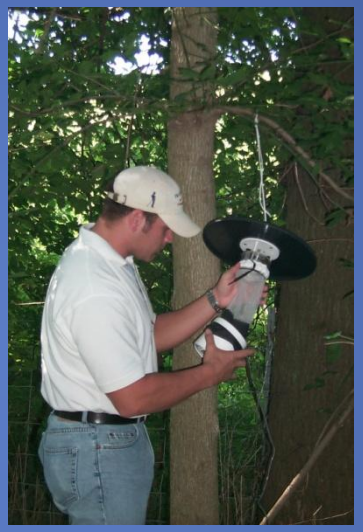




Since treatment for West Nile encephalitis is only supportive care, how can we prevent or interdict WNV epidemics to minimize the number of people infected in an epidemic?

Methods of Predicting WNV Epidemics

- Mosquito trap surveillance



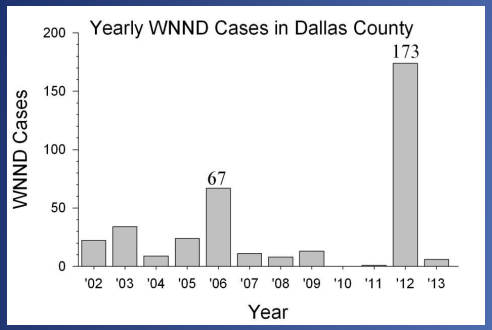
Stagnant water scent attracts gravid mosquitoes preparing to lay eggs after a blood meal, maximizing chance of detecting virus.

Culex quinquefasciatus mosquitoes are separated, counted, and the batch tested for WNV by PCR or culture.

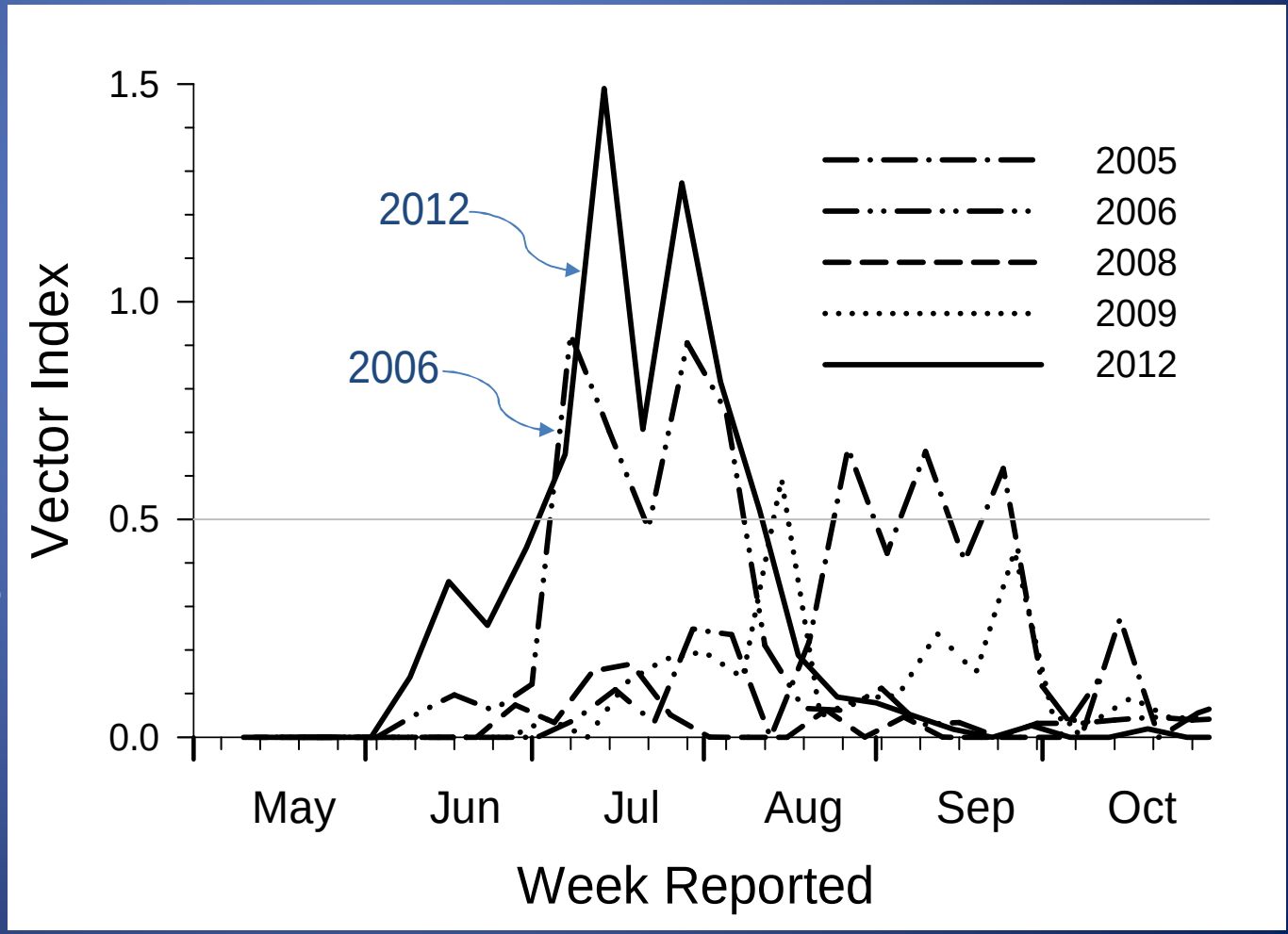
Quantities measured:	Culex abundance	and	Rate (%) of mosquito traps with WNV-positive Culex

Early Warning of a WNV Epidemic By the Vector Index

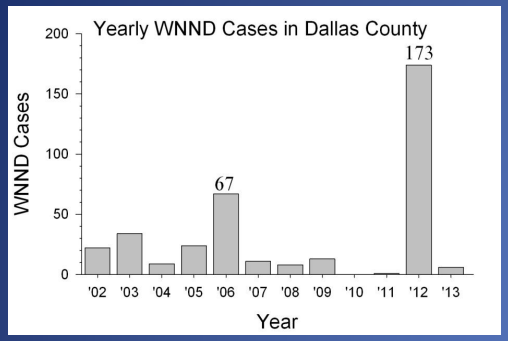
Vector Index = Culex mosquito abundance x Mosquito trap infection rate



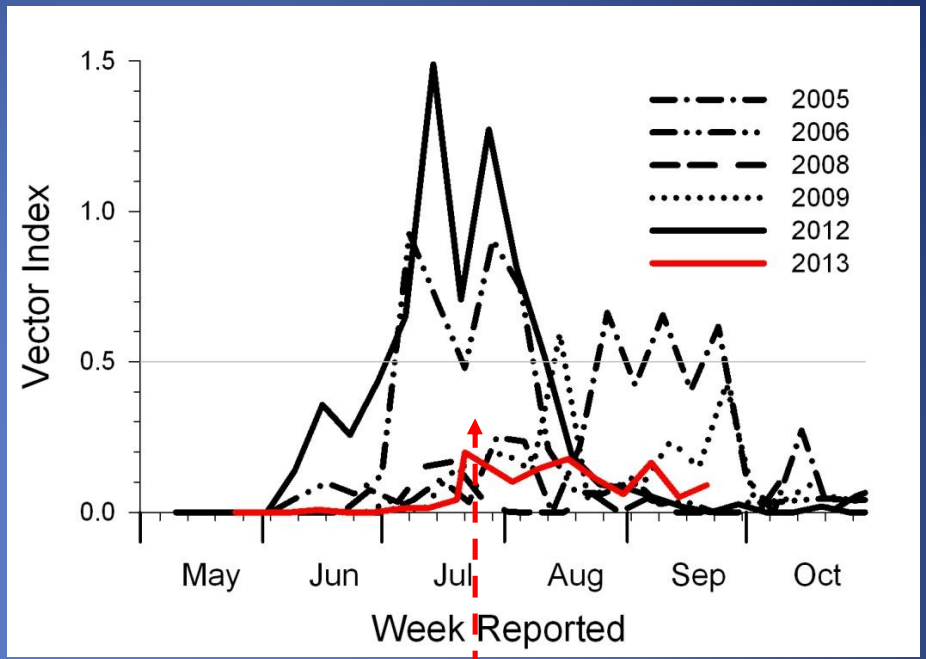
Large epidemics followed vector index >0.5 in June or July.

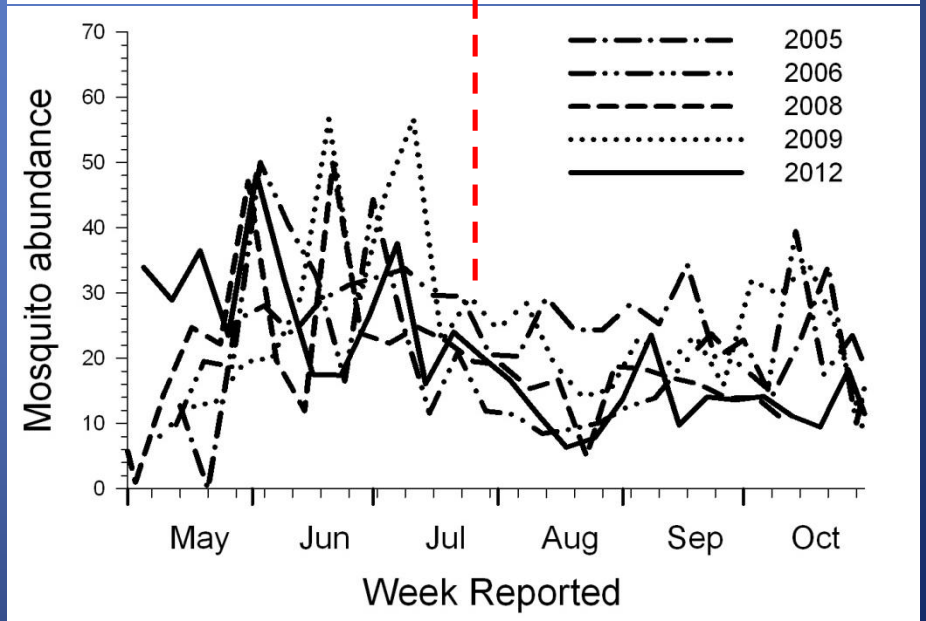


Why do late increases in VI fizzle?



By late July the number of biting female Culex mosquitoes declines, so large epidemics are unlikely to begin.





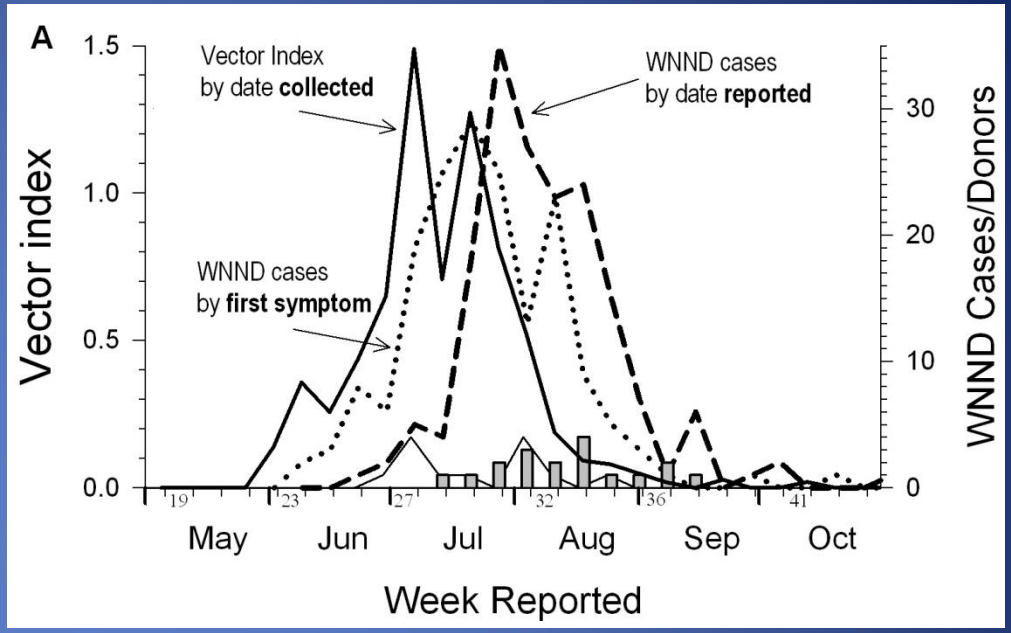
How much lead time does the VI provide?

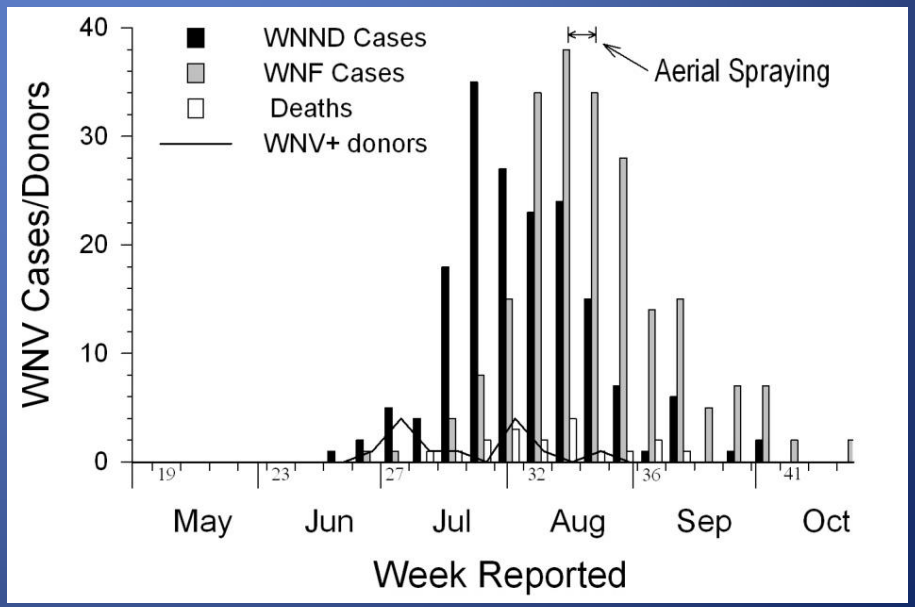
In the 2012 Dallas epidemic, the increase in WNND cases by date of first symptom lagged a week behind the increase in the vector index.

Since the average incubation period from infecting bite to first symptom is 1 week, infecting bites increase at the same time as the vector increases.

Most WNND cases were bit in June through early August.

Aerial spraying in mid-August prevented later recrudescence of the epidemic.





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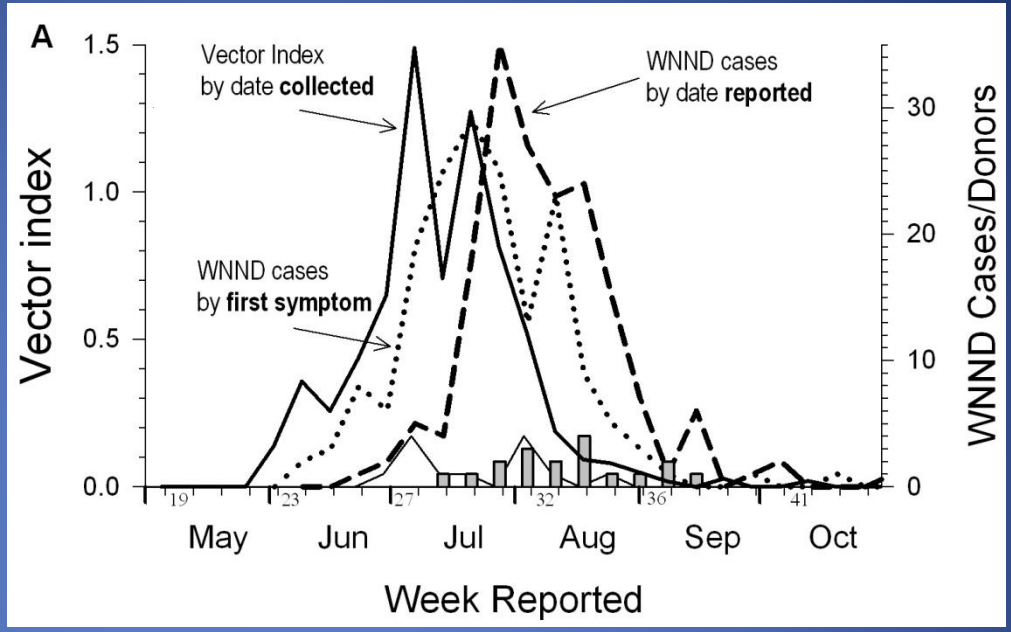
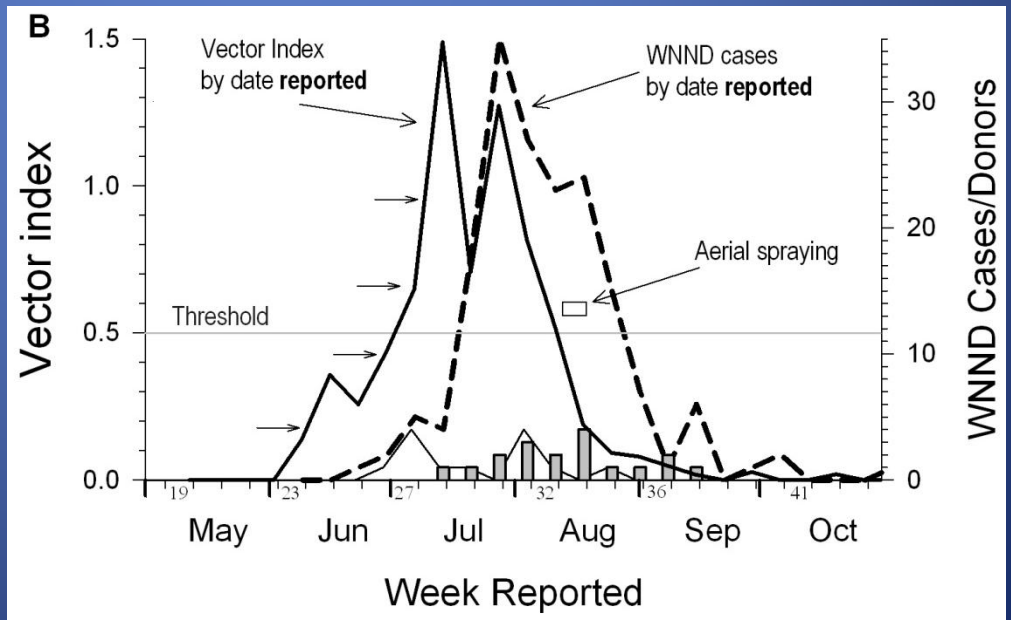


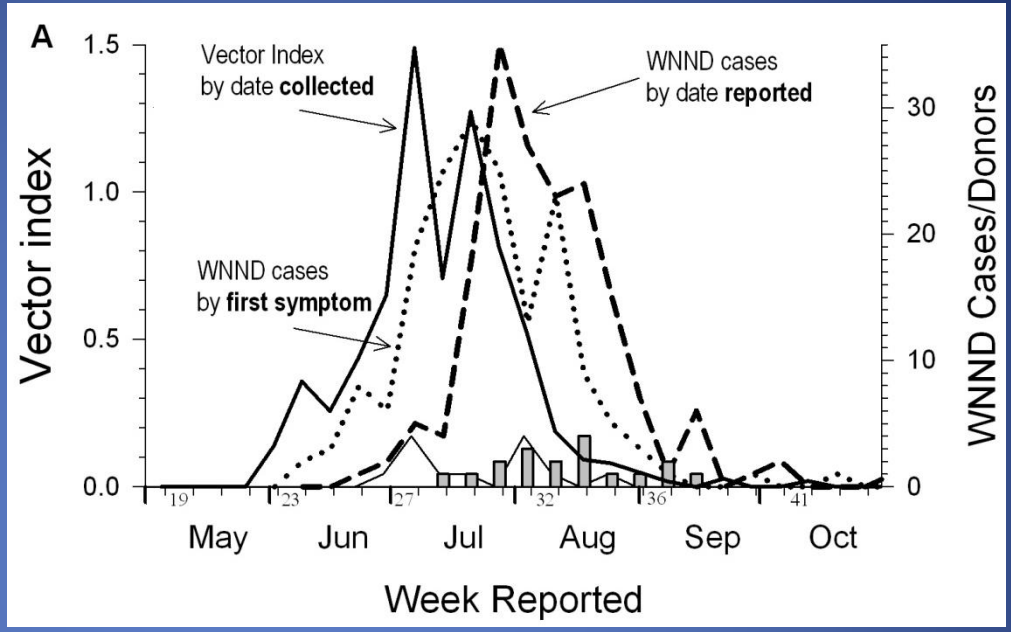


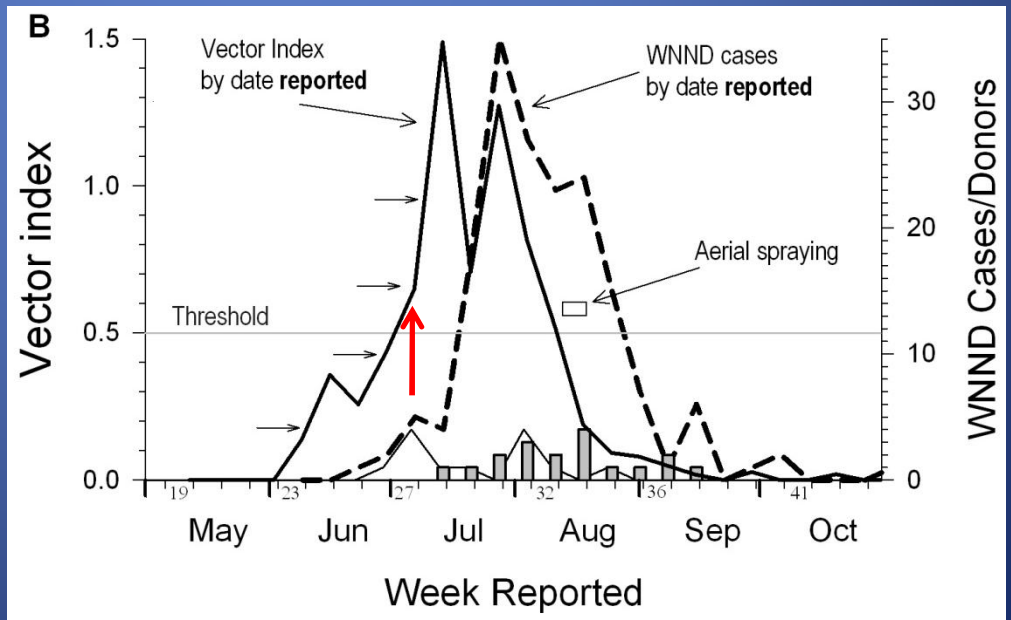
Move the VI to the right one week to allow for processing traps, testing for WNV, and reporting.

Remove the first symptom curve.

This is what the health department sees.

How much lead time does the VI provide?





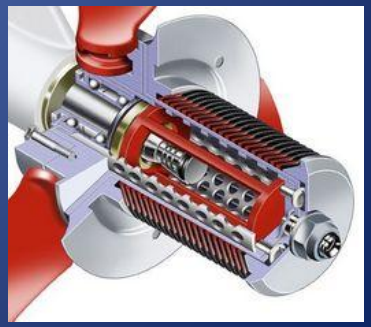
Intervention with immediate aerial spraying the week the VI first was known to exceed the 0.05 threshold might have prevented 110 of the 173 WNND cases and 12 of the 21 deaths.

With early warning, how do you intervene quickly?

Ultra-Low Volume (ULV) Spraying

- Developed in 1950s to 1970s agriculture and disease control
- A rotary atomizer produces tiny droplets 1-150 micron.
- Different species are killed by different size droplets.
  - Mosquitoes are killed by insecticide droplets 5-25 microns.
- Used in trucks or aircraft for mosquito control
- Aerial spraying delivers 30 ml per acre.
- *Duet Dual-Action*® contains 2 pyrethrins and the synergist piperonyl butoxide (PBO, inactivates mosquito P450).
- EPA-approved for use in mosquito control
- Kills 90-100% of mosquitoes in open, 50% under tree cover.
  - *Culex quinquefasciatus* "canopy dwellers" are efficiently killed.



Effect of ULV Aerial Spraying in Dallas, 2012

Aerial spraying covered 73% of area and 83% of population of Dallas Co.

CDC evaluated the 4-county area.

Figure 2. Location of Area 1, Area 2, and Area 3 aerial spray events in northeastern Texas, 2012

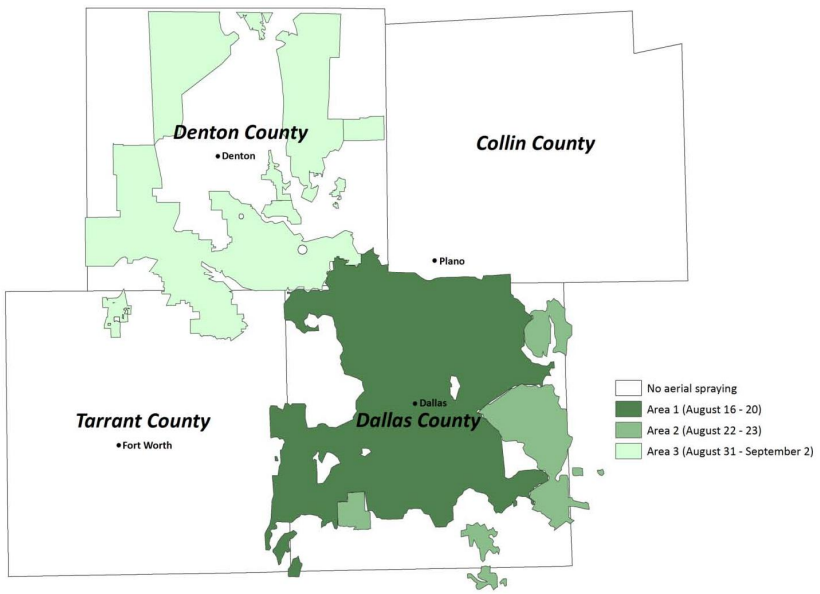


Table 3. West Nile virus neuroinvasive disease cases, incidence rates per 100,000 population, and incidence rate ratios before and after aerial spraying in treated and untreated areas — Collin, Dallas, Denton, and Tarrant Counties, Texas, 2012

	Before aerial spraying			After aerial spraying						
Area	Cases	Population	IR	Cases	Population	IR	IRR*	(95% CI)	Ratio of IRRs†	(95% CI)
Treated	189	2,530,019	7.5	7	2,529,553	0.3	27.0	(12.7-57.4)	**2.55**	**(1.0-6.5)**
Untreated	148	3,085,121	4.8	14	3,084,758	0.5	10.6	(6.1-18.3)		

IR = incidence rates
IRR = Incidence rate ratio
CI = Confidence interval

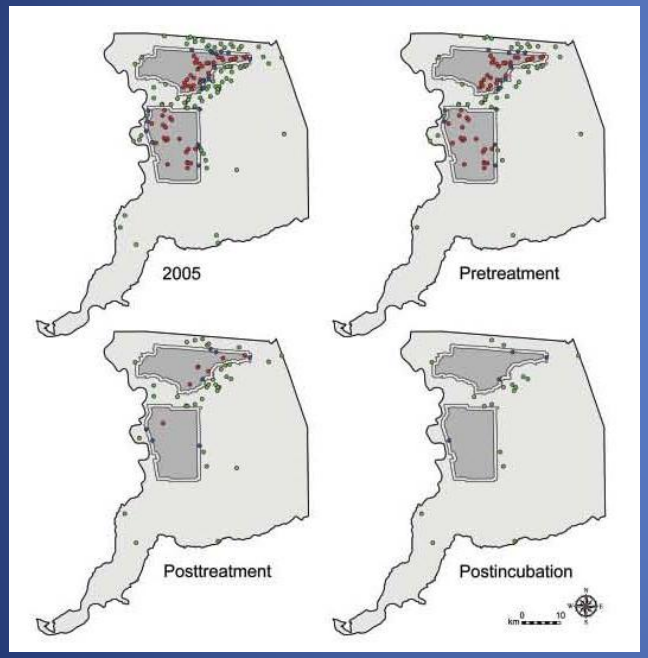
*Incidence rate before aerial spraying/Incidence rate after aerial spraying
†IRR in treated areas/IRR in untreated areas

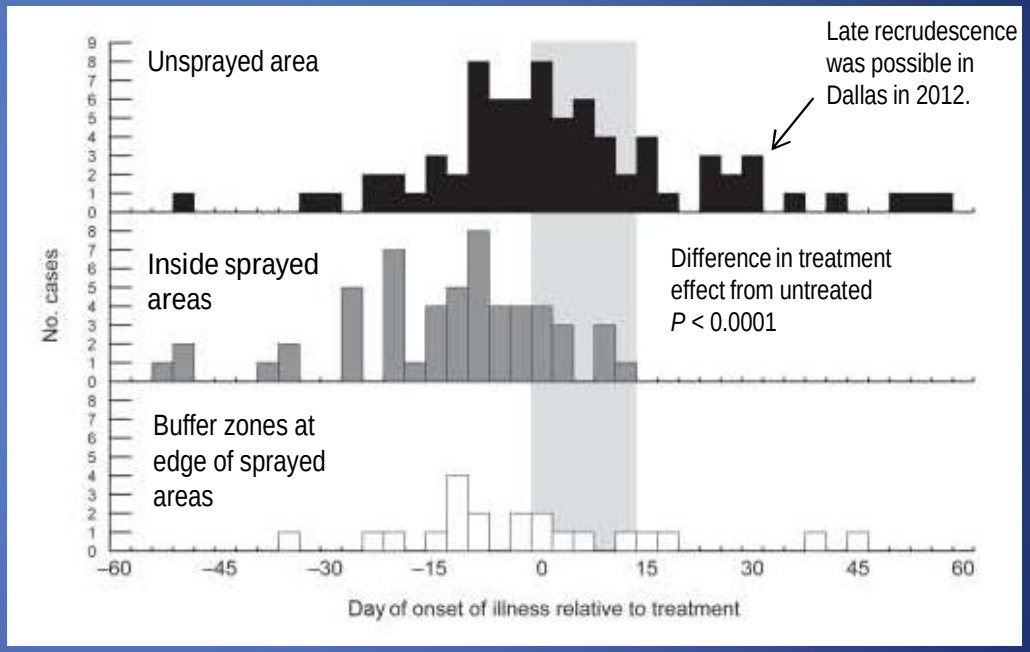
Breslow-Day test for homogeneity of effect $P = 0.042$

CDC Division of Vector-Borne Diseases. *Epi-Aid 2012-069 Final Report*. February 5, 2013

Effect of ULV Spraying on Human WNV Infection Sacramento, 2005

Effect of ULV aerial spraying at 200 feet on 3 consecutive nights





Shaded areas in Yolo Co. (Sacramento) were aerially sprayed. Dots are WNV cases.

Carney et al. *Emerging Infectious Diseases 2008*; 14: 747-754

Is aerial spraying with ULV insecticide mist safe and will the population accept it?

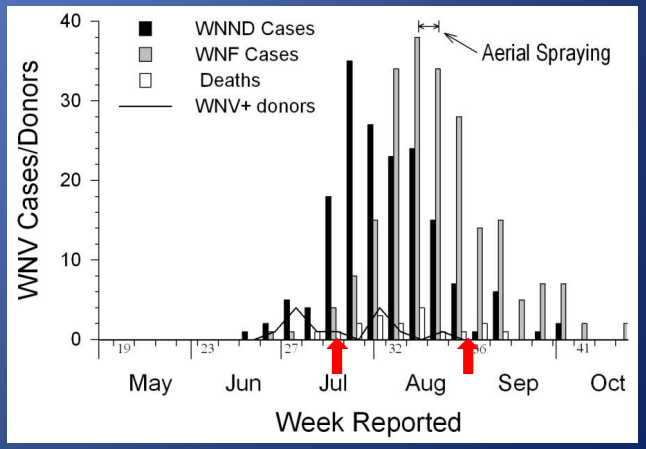
Dallas Morning News Headlines, July 17-August 31, 2012

Jul 17 Death spurs W. Nile fears
Jul 20 West Nile kills HP man (front page)
Jul 21 CHARLES H. PISTER JR. Dallas banker, civic leader, relied on relationships
Jul 28 Third county resident dies from West Nile illness
Jul 31 TOM M. McCrory Dallas eye surgeon, 92, practiced nearly 40 years
Aug 2 W. Nile numbers making history
Aug 7 Doctors urge aerial spraying
Aug 8 Spraying to continue from ground, not air
Aug 9 Mosquito sprays catch other wildlife in toxic net
Aug 9 Man's death is ninth in county
Aug 10 County declares emergency over West Nile virus
Aug 15 Four cities agree to allow aerial spraying
Aug 16 Aerial spraying to begin tonight
Aug 17 Farmers fear spray will endanger bees
Aug 17 Insecticide attack gets off the ground
Aug 18 Call volume calms down at poison control centers
Aug 21 Jenkins takes a risk
Aug 24 West Nile spraying ends after 8 days
Aug 31 Officials say spraying a success

Jim Schutze - *Dallas Observer*

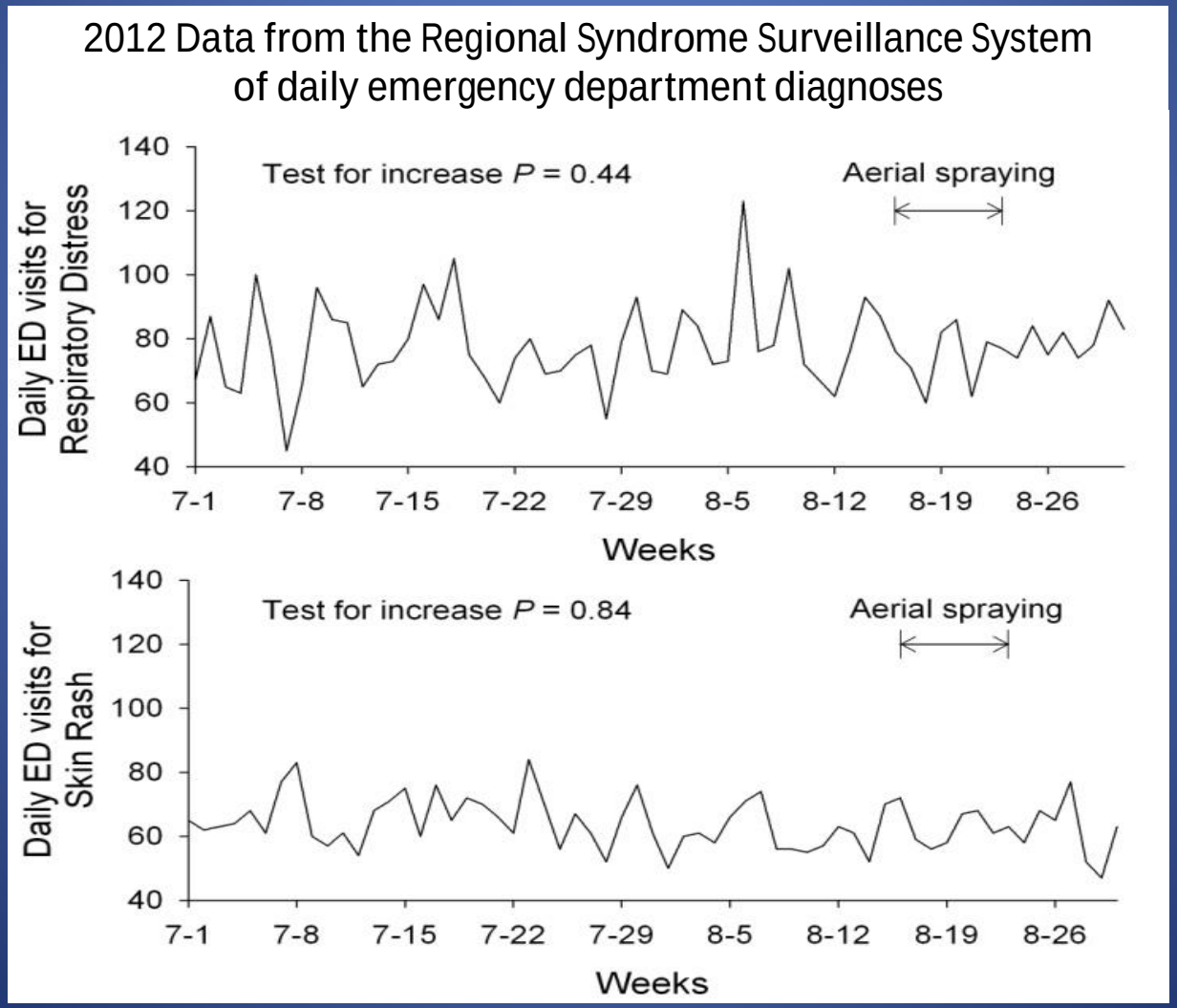
Aug 2 Spraying – Is it safe?

Aug 12 More harm that good?



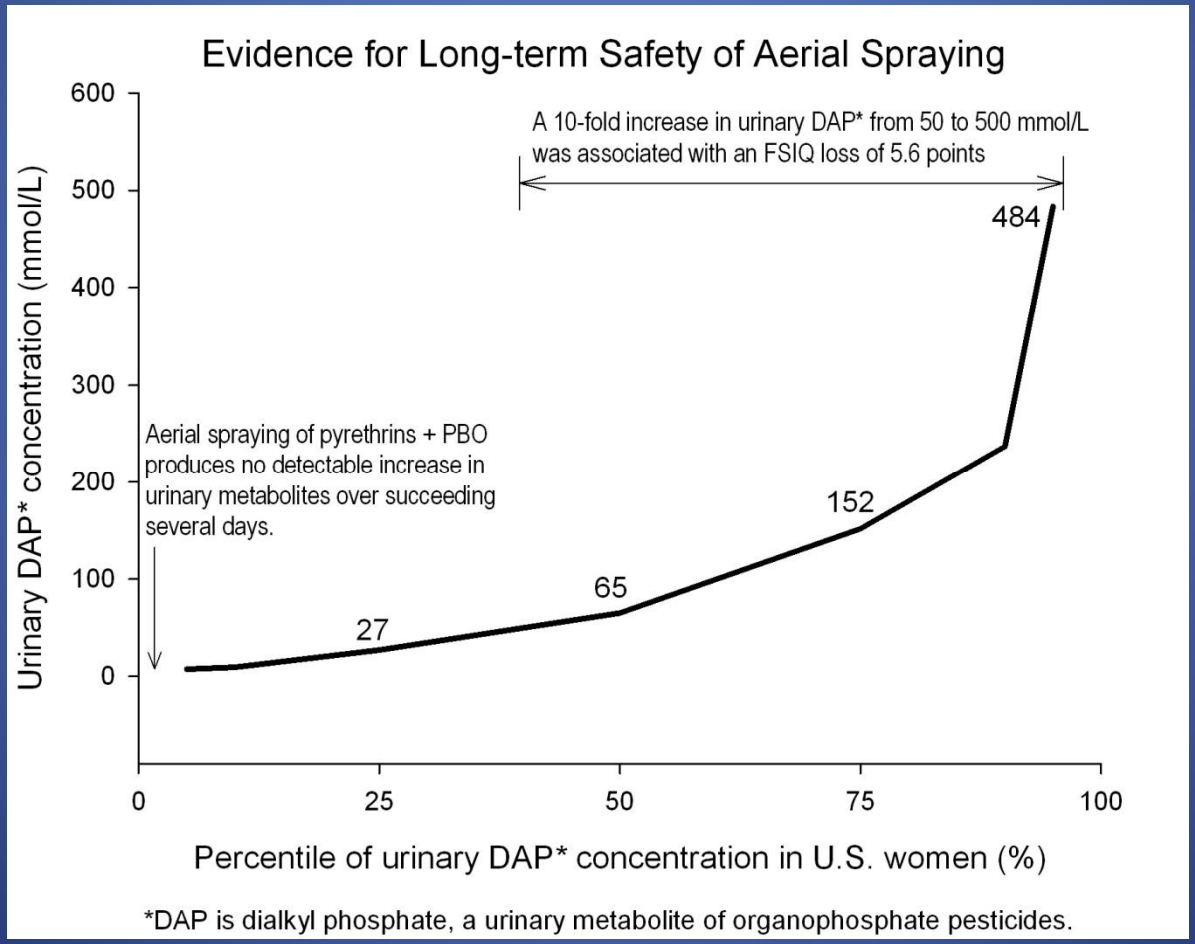
Arguments Against Aerial Adulticiding

- *"Many calls of serious skin rashes and breathing problems after the spraying."* But surveillance data dispelled this rumor.



Arguments Against Aerial Adulticiding

- *"Scientific research shows that pesticide exposure during pregnancy causes brain damage in the fetus that reduces later IQ."*



Graphical adaptation of data from Bellinger. *Environmental Health Perspectives* 2012; 120: 501-507

Provisional Conclusions

- Large WNV epidemics will recur every few years for the foreseeable future.
- The best efforts to prevent or control them with early season larva control or ground spraying will fail.
- Weekly monitoring of the vector index from mosquito trap surveillance will reliably predict impending epidemics 3-4 weeks before cases and deaths rise.
- Immediate rapid aerial spraying when the vector index exceeds the threshold will prevent most cases and deaths.
- This poses a dilemma:

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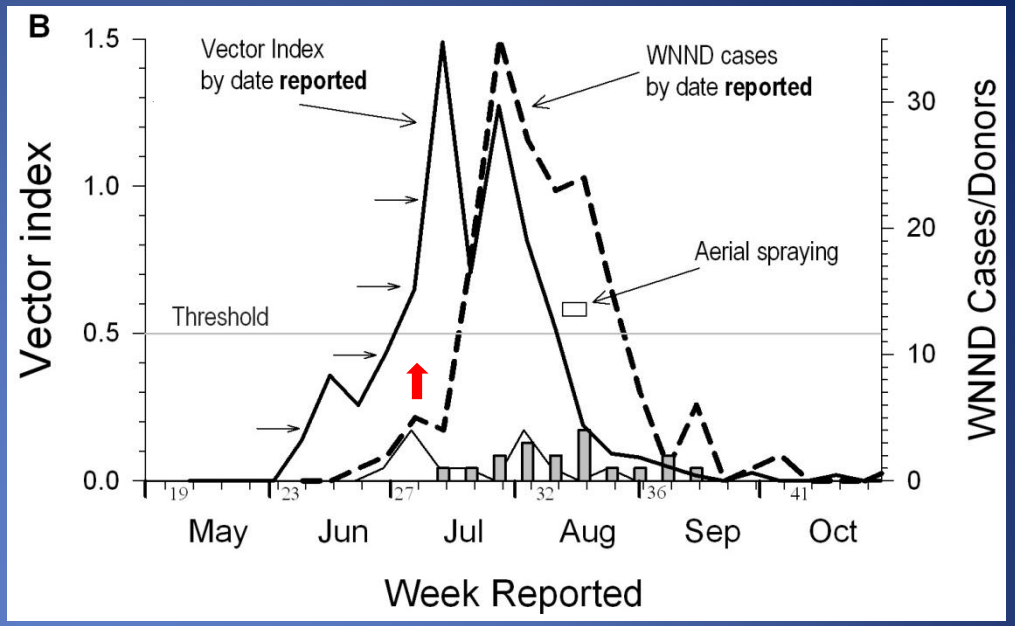
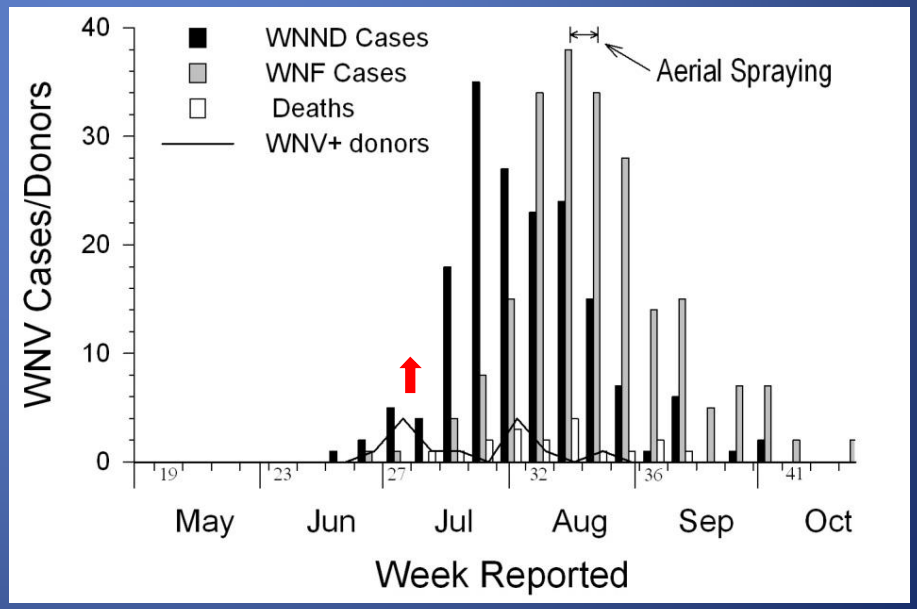
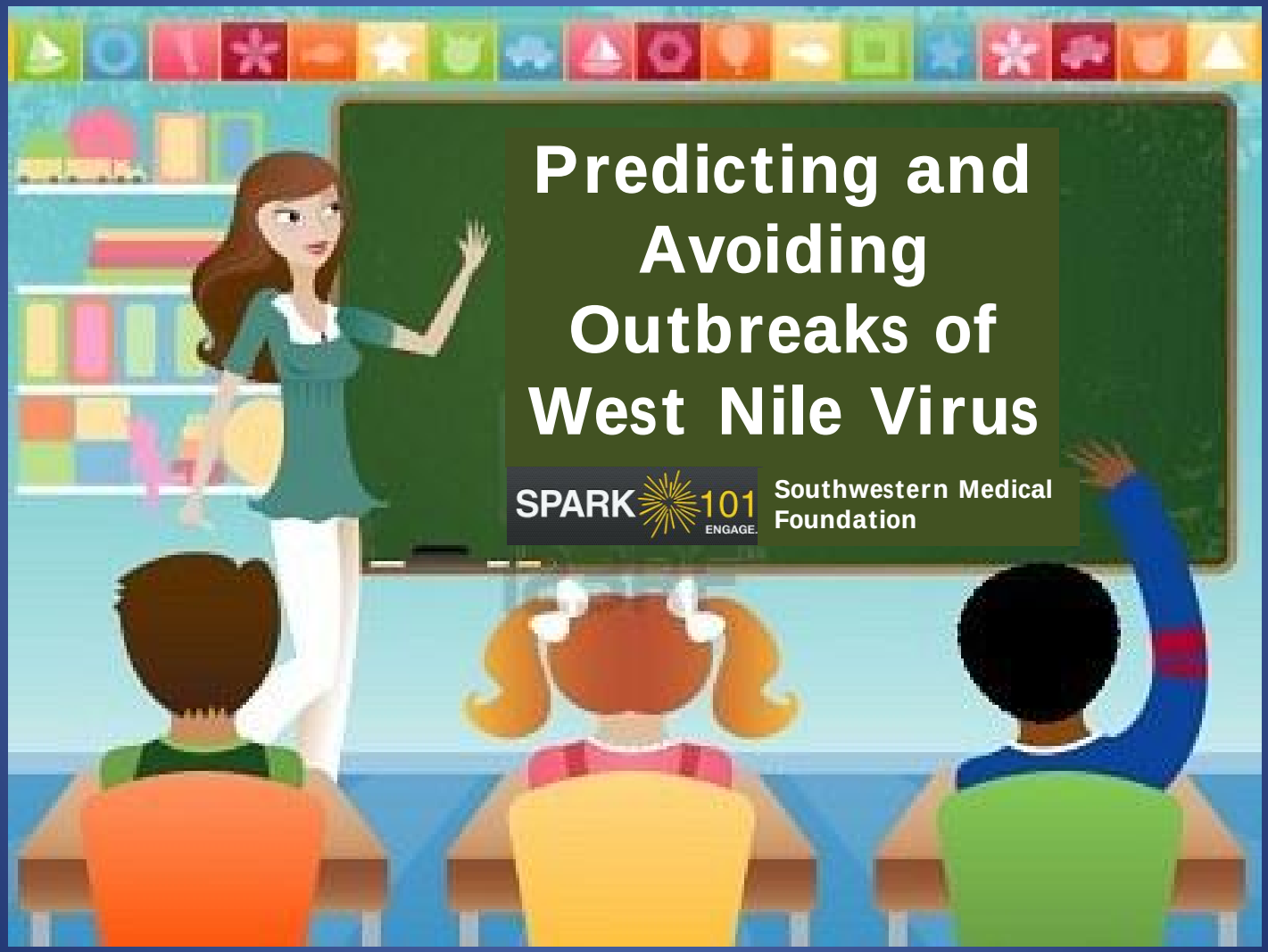




The Story of West Nile Prevention in a 10-Minute Video



http://www.spark101.org/video/predicting-and-avoiding-outbreaks-of-west-nile-vir/

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